IN VITRO MARGINAL FIT OF THE COMPUTER-AIDED MILLED CERCON CROWNS

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Statement of problem. There have been many studies about marginal discrepancy of single restorations made by various systems and materials. But most of statistical inferences are not definite because of sample size, measurement number, measuring instruments, etc. And there have been few studies about the marginal fit of Computer-aided Cercon crowns.

Purpose. The purpose of this study was to compare the marginal fit of the anterior single restorations made using computer-aided milled Cercon crowns with metal-ceramic restorations and to obtain more accurate information by using a large enough sample size and by making sufficient measurements per specimen.

Material and methods. The *in vitro* marginal discrepancies of computer-aided milled Cercon crowns and control groups (metal ceramic crowns) were evaluated and compared. The crowns were made from one extracted maxillary central incisor prepared by milling machine. 30 crowns per each system were fabricated.

Measurements of a crown were recorded at 50 points that were randomly selected for marginal gap evaluation. Parametric statistical analysis was performed for the results.

Results. The means and standard deviations of the marginal fit were $85 \pm 22\mu m$ for the control group and $91 \pm 15\mu m$ for the Cercon crowns. The t-test of the marginal discrepancies between Cercon crowns and metal-ceramic crowns were performed. Significant differences were not found between groups ($P=0.230>.05$).

Based on the criterion of $120\mu m$ as the limit of clinical acceptability, the mean marginal fits of Cercon crowns and metal-ceramic crowns were acceptable.

Conclusion. Within the limitations of this *in vitro* study, the following conclusions were drawn:

1. Mean gap dimensions and standard deviations at the marginal opening for maxillary incisal crowns were $85 \pm 22\mu m$ for the control (metal-ceramic crowns), $91 \pm 15\mu m$ for Cercon crowns.
2. The Cercon crowns showed slightly larger marginal gap discrepancy than the control but marginal gap between Computer-aided milled Cercon crowns and metal ceramic crowns did not showed significant difference ($P>.05$).
3. The Cercon crowns and metal ceramic crowns showed clinically acceptable marginal discrepancy.

Key Words
Marginal fit, Cercon crown, Computer-aided milling system, Metal-ceramic crown

As a result of the requirement to provide patients with excellent esthetics and biocompatible prosthetic dental restorations, the search for ways to fabricate all ceramic crowns, offering long-term clinical stability has been done. The demand for esthetic dental restorations has made the all ceramic crown a popular restoration. If all ceramic restorations are to be successful, they must satisfy strength and marginal fit. Especially, marginal fit is a very important aspect in fixed restorations because large marginal gap show more plaque accumulation, more cement leakage, higher secondary caries occurrence, etc. Although there have been many studies about marginal fit of single restorations fabricated by various systems, their statistical inferences were not so definite because of the relatively small sample size, insufficient measurement number per sample, etc.

Cercon crowns are the CAM-aided all-ceramic system which their framework material consists of zirconium oxide. They insist it is biocompatible, aesthetic and accurately fitting all-ceramic restorations for the anterior and posterior tooth region. In Cercon system, scanning and milling unit Cercon brain is filled to the brim with programming expertise - Non-contact scanning of the wax model, generation of the corresponding data record, milling of the zirconium oxide blank - and at the end - the finished crown or bridge framework (Fig. 1). The exact linear shrinkage, which will take place in the sintering furnace, is compensated for during the milling phase. During milling, the still unsintered objects undergo precisely pre-calculated over-extension. The CAM method enable total control of the design and orientation to the master model by individual and manual carving of the restoration. Then it enters the hot phase. At 1350℃, the single crown coping or bridge framework reaches its optimal strength in the Cercon heat furnace. Processed in a chalky-soft state, then just sintered hard zirconium oxide-TZP (tetragonal zirconia polycrystals).

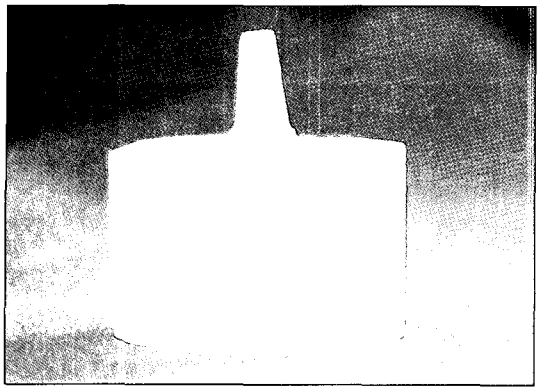
Few studies have been conducted upon the marginal discrepancies of Computer-aided milled Cercon crowns. Coli et al[1] made a study about marginal fit of zirconia dioxide ceramic copings manufactured using a recently introduced CAD/CAM based technique (Denzir), but the number of specimens used for the statictics of marginal gap in each group was.[5]

The purpose of this study was to compare the marginal fits of the anterior single restorations made using the computer-aided milled cercon crowns with metal ceramic restorations.

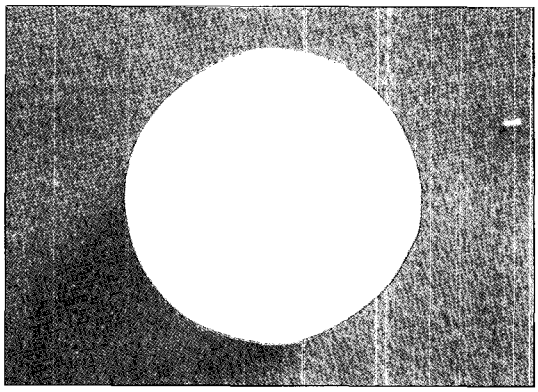
MATERIAL AND METHODS

One extracted maxillary central incisor without caries was cleaned and embedded in an autopolymerizing resin-manufactured block (Orthodontic resin, Dentsply International Inc., Milford, DE). The long axis of the tooth was set perpendicular to the surface of the block. The tooth was prepared for all-ceramic crown fabrication. Using a high-speed handpiece, an incisal reduction of 2-3mm and axial reduction of approximately 1mm was prepared. The tooth was finished by milling (F2, Degussa Korea Inc., Seoul, Korea), which resulted in about a 1mm shoulder margin 6° tapered angles and an approximate height of 7mm (Fig. 1).

A preliminary impression using a stock tray was made using irreversible hydrocolloid impression material (Aroma fine, GC Co., Tokyo, Japan). And a plaster (Samwoo plaster, Samwoo Co., Ulsan, Korea) cast was made. After obtaining the relief of two sheets of baseplate wax on the plaster cast, the 60 custom-made trays were fabricated using acrylic resin (Quicky, Nissan Dental Products Inc., Kyoto, Japan). Final impressions were made with polyvinyl siloxane (Examix, GC Korea Inc., Seoul, Korea) using custom trays, 60 master stone dies were fabricated (Rhombrock, Mitsubishi, Tokyo, Japan)(Fig. 2). Sixty veneered crowns (30 crowns per group) were



A. Labial view



B. Incisal view.

Fig. 1. The prepared the maxillary central incisor was cleaned and embedded in a self-curing resin block. The long axis of the tooth was perpendicular to the block.

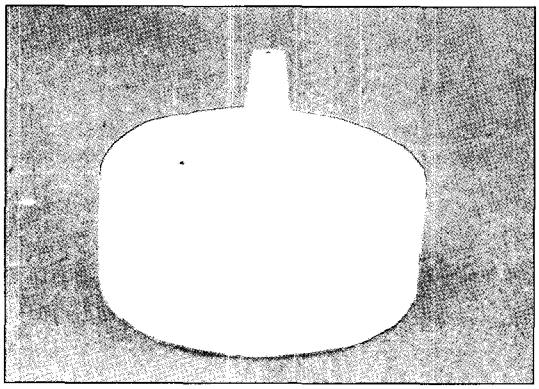
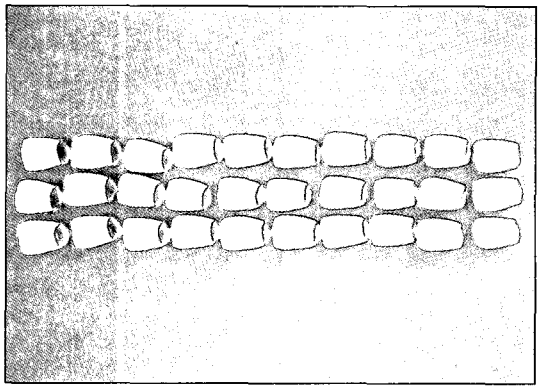
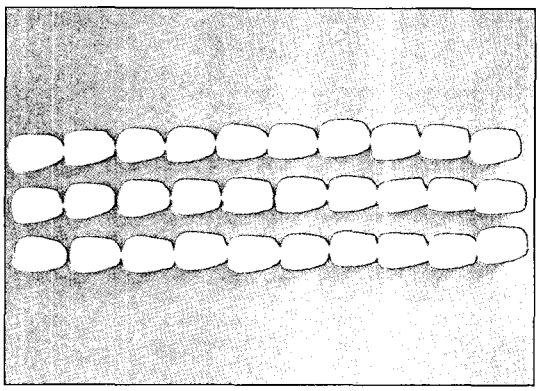


Fig. 2. The master die for final restoration.



A. metal ceramic crowns (n=30)



B. Cercon crowns (n=30)

Fig. 3. Sixty crowns were fabricated.

fabricated; 30 metal ceramic (Rexillium III, JENERIC/PENTRON Inc., Wallingford, Conn. and VMK 95, VITA Zahnfabrik, Bad Säkingen, Germany) crowns, 30 computer-aided milled Cercon crowns (Cercon smart ceramics, Cercon Ceram S, DeguDent, Germany) were made (Fig. 3). Each group of crowns was fabricated by an experienced dental technician who was accustomed to specific system. Cercon crowns were fabricated by scanning and milling unit (Cercon® brain, DeguDent, Germany) (Fig. 4). The marginal fit was evaluated by measuring the gap between the edge of the crown and the prepared tooth margin in a light microscope with image processing (Acura 2000, INTEK PLUS, Daejon, Korea) at X240 magnification (Fig. 5). The accuracy of this light microscope is $\pm 0.1\mu$m. The gap was measured as the minimum distance from one point of the crown edge to a line determined by least squares of points at the tooth margin (Fig. 6). All measurements and the least squared lines were computed by the programmed macro provided by Acura 2000 software system. Measurements were made without cementation. The marginal gap of one crown was measured at 50 points along the margin that were randomly selected in distances of about 400 μm. The marginal fit of one crown was defined as a mean value

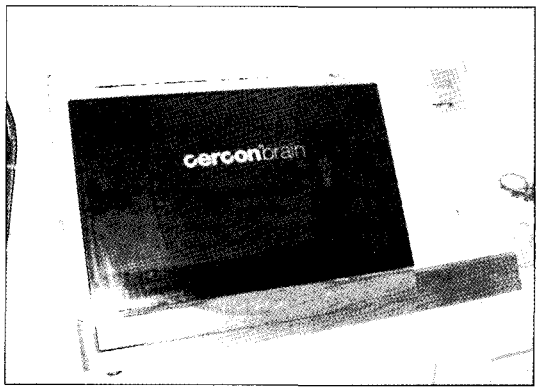


Fig. 4. The Cercon® Brain (DeguDent).

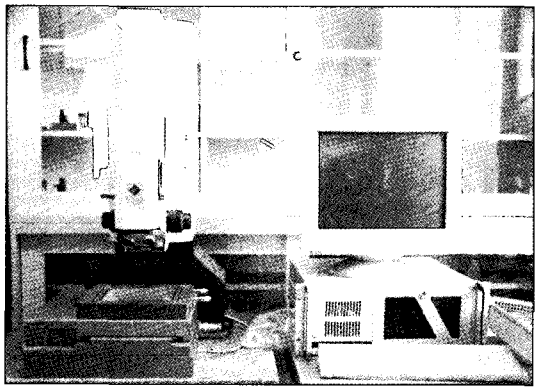


Fig. 5. The light microscope with image processing (Acura 2000).

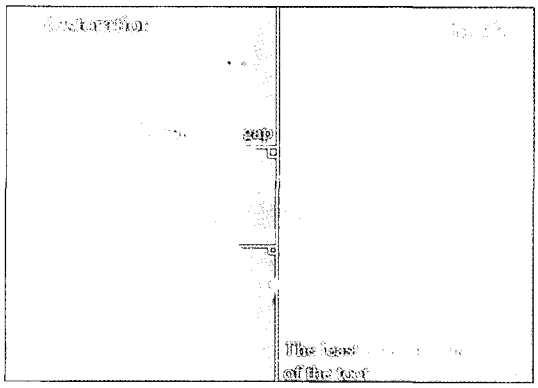


Fig. 6. Demonstration of computer aided measurement of marginal fit.

of these 50 measurements. Groten et al[2], reported that 50 measurements along the margin of a crown yielded clinically relevant information and a consistent estimate for the gap size and that error size for the calculation of the measurement' s mean is about ±5㎛. The means and standard deviations of the marginal fit were, therefore, rounded to 1 ㎛ level.

The means and standard deviations per group were calculated and statistical inferences among the groups were made using t-test at .05 level of significance.

RESULTS

Table I showed the means and the standard deviations of the average gap dimensions of the crown groups. The means and standard deviations of the marginal fit were 85±22㎛ for the control group. 91±15㎛ for the Cercon crowns. The t-test of the marginal discrepancies between Cercon crowns and metal-ceramic crowns (Table II) were performed. Significant differences were not found between groups (P=0.230>.05). Table III presents the normal distribution of the data around the mean value in each group.

Based on the criterion of 120㎛ as the limit of clinical acceptability, the mean marginal fits of Cercon crowns and metal-ceramic crowns were acceptable.

Table I. The mean and standard deviations of marginal fit in each of the groups (unit:㎛).

	N	Mean	Standard Deviation	Standard Error Mean
Metal ceramic	30	85	22	4.09
Cercon	30	91	15	2.78

DISCUSSION

According to Beschnidt et al,[3] the evaluation of the marginal discrepancy of crowns depends on several factors in general: measurements of cemented or not-cemented crowns, storage time and treatment (such as aging procedures) after cementation, kind of abutment used for measurement, kind of microscope and enlargement factor used for measurements, location and quantity of single measurements. Ideally, for measuring the marginal gap after cementation, the same number of teeth or steel dies as that of restoration sample is needed be-

Table II. The result of Independent Sample Test.

	Levene' s Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Standard. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	2.192	.144	-1.213	58	.230	-6.00	4.95	-15.90	3.90
Equal variances not assumed			-1.213	51	.231	-6.00	4.95	-15.93	3.93

Table III. Distribution of the data.

A. metal ceramic crown.

N	Valid	30
	Missing	0
Mean		84.5966
Standard Error of Mean		4.09456
Median		79.3150
Mode		54.09
Standard Deviation		22.42685
Variance		502.963
Skewness		1.450
Standard Error of Skewness		.427
Kurtosis		2.674
Standard Error of Kurtosis		.833
Range		95.09
Minimum		54.09
Maximum		149.18
Sum		2537.90

B. Cercon crown

N	Valid	30
	Missing	0
Mean		90.5963
Median		90.094
Mode		63.66
Standard Deviation		15.20308
Variance		231.134
Skewness		0.336
Standard Error of Skewness		0.427
Kurtosis		0.003
Standard Error of Kurtosis		0.833
Range		61.54
Minimum		63.66
Maximum		125.2
Sum		2717.89

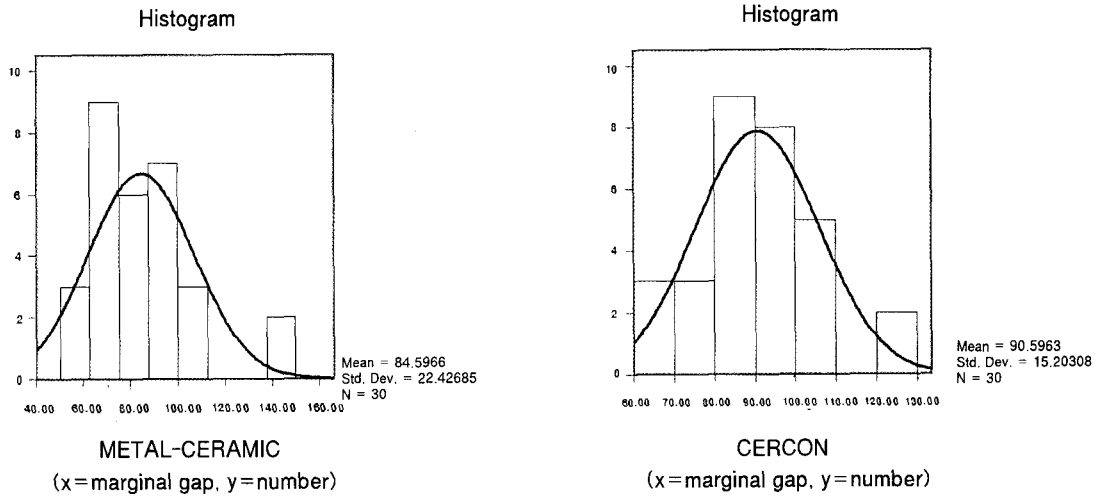


Fig. 7. Distribution of the Data.

cause of the control of variables. On the contrary, only one tooth or steel die is needed if we measure without cementation. Some authors[3,4,5] said that a significant increase in the marginal discrepancy was observed after cementation. They showed, however, considerable different results according to the kinds of cementing medium. The marginal opening was, therefore, measured without cementation for more sophiscated variable control in this study. The marginal discrepancies found in this study were all

within clinically acceptable standards.[9]

In tooth preparation, some forms of the margin are possible: shoulder, heavy chamfer, etc. It was said that the type of finishing line did not affect the marginal gap.[6] According to Goodacre et al,[7] the shoulder margin was recommended in all ceramic restorations and many authors usually agreed with such a marginal design. In this study, therefore, this type of margin was chosen. In the control group, metal ceramic crowns, chamfer margin is selected at the lingual surface. But, two teeth would have been required (one: all shoulder margin, the other: about 1/2 of shoulder, 1/2 of chamfer) in such a case. Then, the two teeth could have different conditions in measuring the marginal opening and there could be a problem in the control of variables. For unification of conditions, all the surfaces of the tooth were prepared with the shoulder margin of about 1mm width and it was used as the only master model.

There has been few study about marginal fit of Cercon crowns. Similar study has been done by Tinschert et al.[8] They reported marginal gap of alumina- and zirconia-based fixed partial dentures produced by a CAD/CAM system (Precident DCS system) and their marginal gap was smaller than this study. But their sample size is too small and they use non-parametric analysis. Hertlein[9] reported similar system, CAD/CAM zirconia based all-ceramic system (3M Lava) has smaller marginal gap. But their sample size is also small. Coli et al[1] made a study about marginal fit of zirconia dioxide ceramic copings manufactured using a recently introduced CAD/CAM based technique (Denzir). The number of specimens used for the statistics of marginal gap in each group was small and 24 measurements per specimen are contributed to the variation.

Variation exists regarding what constitutes a clinically acceptable margin. McLean and von Fraunhofer[10] propose that a successful restoration was possible if restorations could be constructed so that marginal gaps and cement films of less than 120 μm were achieved. This criterion has been cited in some articles. The value of 120 μm was, therefore, used as the maximum clinically acceptable marginal opening in this study

There are no definite standards for the proper sample size and number of measurements for each sample. In many articles, nonparametric statistical analysis was used in evaluating the marginal opening because it was very difficult to obtain the normal distribution of the data. When the sample size was 10, non-parametric analysis was chosen in marginal gap measurement because standard deviations were relatively large compared with mean values, resulting in failure in acquiring normality. However, the parametric analysis is more reliable in evaluating the original population than the non-parametric one. On the statistical side, parametric tests are advocated if normality of the data of the samples can be obtained. When the sample size is high (at least 30), the distribution of data is usually normal. Table III showed that the distribution of data were normal. According to Groten et al,[2] approximately 50 measurements along the margin of a crown yield clinically relevant information and a consistent estimate for the gap size and it was of minor importance whether 50 measurements along the margin were randomly selected or systemically recorded in distances of about 500 μm (strategic 50 measurements). Contrary, Gassino et al.[11] reported that minimum number of measurements required to ensure relevant results for gap analysis was 18 for experimental crowns. In this study, 30 sample sizes and 50 measurements per sample in random manner were selected for more accurate result.[12]

It was considered that there were two variables that were distinguished between the groups in this experimental design: one was the difference between the systems and the other the difference between the skills of dental technicians who made the single restorations. It was assumed in this study that there was no difference in the technique of the dental

technicians, because they had fabricated more than 500 crowns using each system, and were considered experienced. It was, therefore, thought that the difference between the systems was the only significant variable and that the other conditions were identical. The present study showed clinically acceptable marginal discrepancy of all groups.

There were some limitations in this study. Marginal opening is measurable in this experimental design. Internal fit of the crowns is impossible to measure. In order to measure the inner fit of artificial crowns, cementing the crowns and sectioning the specimens are required. In case of new experimental design to measure both the marginal and inner fit are required.

Cercon anterior fixed partial dentures as well as single crowns have been applied for aesthetics. It requires more strength and dimensional stability that has resulted in clinically acceptable marginal fit. More studies are necessary about strength and marginal fit of Cercon fixed partial dentures.

CONCLUSIONS

Within the limits of this study, the following conclusions were drawn:

1. Mean gap dimensions and standard deviations at the marginal opening for maxillary central incisor crowns were $85 \pm 22\mu m$ for the control (metal-ceramic crowns), $91 \pm 15\mu m$ for Cercon crowns.
2. The Cercon crowns showed slightly larger marginal gap discrepancy than the control but marginal gap between Computer-aided milled Cercon crowns and metal ceramic crowns did not showed significant difference.
3. The Cercon crowns and metal ceramic crowns showed clinically acceptable marginal discrepancy.

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